



**UNITED STATES DEPARTMENT OF COMMERCE**  
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Alaska Fisheries Science Center  
Resource Assessment and Conservation  
Engineering Division  
7600 Sand Point Way Northeast  
BIN C15700, Building 4  
Seattle, Washington 98115-0070

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**CRUISE RESULTS**  
**NOAA SHIP MILLER FREEMAN**  
**Cruise No. 89-05**

**RESULTS OF THE TRIENNIAL ACOUSTIC-MIDWATER TRAWL**  
**SURVEY OF PACIFIC WHITING ALONG THE WEST COAST IN 1989**

by  
Edmund P. Nunnallee

**INTRODUCTION**

The triennial acoustic-midwater trawl survey of the Pacific whiting (Merluccius productus) population along the west coast of the United States was conducted using the National Oceanic and Atmospheric Administration (NOAA) vessel Miller Freeman during the periods July 22-August 4 and August 7-25. The survey was comparable in extent to those conducted in 1977, 1980, 1983, and 1986. The major objective was to provide data for estimation of age and size specific biomass and population.

**SURVEY AND ANALYSIS METHODS**

Acoustic data were collected with a 38 Khz echo sounder and a digital echo integrator. The echo sounder's transducer was housed in a dead weight vehicle that was towed behind the ship by an electro-mechanical cable at a depth of about 20 m. The acoustic data collection system was housed in a portable van mounted on the weather deck of the ship. Calibration of the system was accomplished in the following two ways: an indirect method using an acoustics measurement barge before and after the cruise and a direct (in situ) method using a standard sphere suspended under the transducer. Acoustic barge measurements were used to determine the directivity pattern of the transducer while the in situ ball method supplied the remaining parameters necessary to scale echo integration values to fish density ( $\text{Kg/m}^3$ ). The in situ calibrations were conducted during the first and last 2 days of the cruise.



Survey data were collected along a series of parallel tracklines spaced 10 nm apart and oriented east-west between the 55 m (30 fm) and 366 m (200 fm) depth contours. The survey was started at Pt. Conception, California (34° 30' N. Latitude), and ended off northern Vancouver Island (50° N. Latitude). A chart showing the survey area and transect locations is presented in Figure 1. All midwater trawling and acoustic data collection was conducted during daylight hours to avoid contamination by non-target species which ascend from bottom into the water column at night. Vessel speed along the transects was usually 10-11 kn. Echo integration data were collected to within 3 m of bottom.

Trawl hauls were made throughout the survey with a Northern Gold rope trawl. Hauls were made on selected echo sign to identify the scatterers and to provide information on the biological composition of Pacific whiting and other species. The trawl was equipped with 5 m<sup>2</sup> doors and 455 Kg (1,000 lb) tom weights and the codend was equipped with a 3.2 cm (1.25 in) liner. An acoustic linked headrope sounder was used to monitor the mouth opening, usually 15-18 m (8-10 fm), and the position of the trawl in the water column. On-deck sampling procedures were used to obtain randomized samples of target fish species from each catch. Catches of less than about 2,000 lb were sorted completely. Larger catches were subsampled using a splitting net and the subsamples were sorted. Species compositions of all trawl catches were determined in terms of weight and numbers. A randomized subsample of whiting (300-400 fish) was taken from the sorted portion of each catch for detailed examination and biological sample collection (size measurements, age structures, sexual maturity, sex ratio, individual weights, etc.). Trawl station locations were selected on an opportunistic basis (by appearance, depth, density, etc.) in order to identify and categorize the species compositions and biological components of fish represented by the various layers and groups of echo sign encountered during the survey.

## RESULTS

### Sampling Effort and Biological Data Collection

Total trackline distance, during which hydroacoustic data were continuously collected, amounted to approximately 2,500 nm. Twenty-five midwater trawl hauls were conducted throughout the survey area. The occurrences of species taken by midwater trawl, a summary of haul locations, durations and catch quantities, and a list of the biological data collected during the cruise are given in Tables 1, 2 and 3, respectively. Most of the trawl catches consisted mainly of Pacific whiting. The percentage by weight represented by all species other than Pacific whiting in all trawl hauls combined amounted to only 2.2%. The small proportion of non-target species in trawl haul catches is not representative of the actual abundance of those species in the survey area. In most instances, the echo sign of non-target species was readily discernable and was not sampled.

### Distribution, Abundance and Size

Significant whiting aggregations were found from about 37° 10' to 50° 00' N. Latitude. The bulk of the whiting stock occurred, in order of abundance, in the Eureka, Columbia (S), and Monterey International North Pacific Fisheries Commission (INPFC) areas, respectively. The approximate locations of all of the whiting aggregations encountered during the survey are given in Figure 2. Table 4 lists estimated biomass by INPFC area (Figure 1). Age 0 whiting (1989 Year Class) were found only in the Conception INPFC area where they were in small, isolated aggregations that were associated with large quantities of non-fish echo sign. The abundance estimates given in this report for these fish should be used only as an indication of their presence, since the degree of contamination of their echo sign by other organisms could not be determined with confidence. A small amount of age 1 whiting (1988 Year Class) were found only in the Monterey area. Age 2 whiting were found in moderate abundance in the Monterey and Eureka areas and were in low abundance in the Columbia (S) area. Age 5 and 9 whiting (1984, 1980 Year Class) were the most abundant of all aged 3 and older cohorts in all areas except Conception. They contributed about 79% by numbers and 84% by weight (age 0 numerical and biomass estimates disregarded) to the total pelagic portion of the whiting population. Tables 5 and 6 present estimated population numbers and biomass by length and age, by INPFC area. Figures 3, 4, 5, and 6 are graphical presentations of population numbers and biomass by length and age, by INPFC area.

A consistent trend of increasing mean length with latitude was noted for 5 and 9 year old whiting from the Monterey-Eureka to Vancouver INPFC areas (Table 7, Figure 7). A similar trend may be applicable to other year classes, but the sample sizes of aged whiting within those groups was not sufficient for a meaningful analysis for this data set. The trend was first documented by Ermakov (1974). His interpretation of the phenomenon was that large whiting travel farther north during their summer migration than smaller ones, indicating differential swimming speed for large versus small fish. Dorn (in prep) has also documented the trend and he too attributes the phenomenon to the differential swimming speed of the fish. An indirect indication that the size of Pacific whiting is a factor in their distribution along the West Coast is presented by Dorn and Methot (1990). Commercial catch data presented by the authors show that peak catch rates for consecutive year classes in U.S. waters consistently occur 2 or more years before those for the same year classes in Canadian waters. Dorn and Methot offer no hypothesis as to the different timing of peak year class catch rates, but it presumably is due to differences in availability of the fish to the two fisheries; the fish are older and larger before they arrive in quantity in Canadian waters.

## SCIENTIFIC PERSONNEL

Leg I

William A. Karp	Chief Scientist	AFSC, Seattle
John Garrison	Electronics Technician	AFSC, Seattle
Don Pearson	Fishery Biologist	SWFSC, Tiburon
Dan Twohig	Electronics Technician	AFSC, Seattle
Dan Varoujean	Wildlife Biologist	Envirosphere
Dan Lewis	Wildlife Biologist	Envirosphere
Mikhail Stepanenko	Fishery Biologist	U.S.S.R.
Genady Portnov	Fishery Biologist	U.S.S.R.

Leg II

Edmund Nunnallee	Chief Scientist	AFSC, Seattle
Taina Honkalehto	Fishery Biologist	AFSC, Seattle
Joseph Klein	Fishery Biologist	AFSC, Seattle
Dan Twohig	Electronics Technician	AFSC, Seattle
George Kautsky	Fishery Biologist	WDF, Seattle
Dan Varoujean	Wildlife Biologist	Envirosphere
Gregory Green	Wildlife Biologist	Envirosphere

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AFSC - Alaska Fisheries Science Center  
 SWFSC - Southwest Fisheries Science Center  
 WDF - Washington Department of Fisheries

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- Ermakov, Y. K. 1974. The biology and fishery of Pacific hake, *Merluccius productus*. Ph.D. Thesis, Pac. Sci. Inst. Mar. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R. [in Russ.]
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- Dorn, M. and R. Methot. 1990. Status of the Pacific whiting resource in 1989 and recommendations to management in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-182, 84 p.

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For further information, contact Dr. Gary Stauffer, Director, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, 7600 Sand Point Way NE., BIN C15700, Bldg. 4, Seattle, WA 98115-0070. Telephone (206) 526-4170.

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Table 1. Occurrences, ranked by numbers of hauls, of fish species taken by midwater trawl during the West Coast whiting cruise, MF89-05.

Rank	Freq	Common Name	Species
1	23	Pacific Whiting	<u>Merluccius productus</u>
2	13	Jellyfish	Scyphozoa
3	5	Squid	<u>Loligo opalescens</u>
4	5	Salps	Scyphozoa
5	4	Spiny Dogfish	<u>Squalus acanthias</u>
6	4	Jack Mackerel	<u>Trachurus symmetricus</u>
7	3	Sablefish	<u>Anoplopoma fimbria</u>
8	3	Squid (unident)	Cephalopoda
9	3	Shortbelly Rockfish	<u>Sebastes jordani</u>
10	2	Yellowtail Rockfish	<u>Sebastes flavidus</u>
11	2	Lanternfish (unident)	Myctophidae
12	2	Pacific Ocean Perch	<u>Sebastes alutus</u>
13	2	Whitebait Smelt	<u>Allosmerus elongatus</u>
14	1	Smelt (unident)	Osmeridae
15	1	Pink Salmon	<u>Oncorhynchus gorbuscha</u>
16	1	Aurora Rockfish	<u>Sebastes aurora</u>
17	1	Widow Rockfish	<u>Sebastes entomelas</u>
18	1	Greenstripe Rockfish	<u>Sebastes elongatus</u>
19	1	Splitnose Rockfish	<u>Sebastes diploproa</u>
20	1	Chilipepper	<u>Sebastes goodei</u>
21	1	Stripetail Rockfish	<u>Sebastes saxicola</u>
22	1	Black Rockfish	<u>Sebastes melanops</u>
23	1	Sand Sole	<u>Psettichthys melanostictus</u>
24	1	Rex Sole	<u>Glyptocephalus zachirus</u>
25	1	Dover Sole	<u>Microstomus pacificus</u>
26	1	English Sole	<u>Parophrys vetulus</u>
27	1	Flathead Sole	<u>Hippoglossoides elassodon</u>
28	1	Sanddab (unident)	<u>Citharichthys</u> sp.
29	1	Lingcod	<u>Ophiodon elongatus</u>
30	1	Pacific Tomcod	<u>Microgadus proximus</u>
31	1	Pacific Sardine	<u>Sardinops sagax</u>
32	1	Skate (unident)	Rajidae
33	1	Spotted Ratfish	<u>Hydrolagus colliei</u>
34	1	Pacific Electric Ray	<u>Torpedo californica</u>
35	1	Box Crab	<u>Parapagurus pliosimanus</u>

Table 2. Trawl haul locations and catch summary for West Coast Pacific whiting survey cruise MF 89-05

HAUL #	DATE	EQUIL HOUR	FTROPE/ BOTTOM DEPTH (m)	START		END		CATCH WEIGHTS				
				LAT	LOE	LAT	LOE	PACIFIC WHITING	ROCKFISH SPECIES	JACK MACKEREL	UNIDENT JELLYFISH	OTHER
1	07/24	13	89/118	34 50.5	120 53.2	34 50.5	120 53.2	103	-	-	2	T
2	07/24	15	35/115	34 49.8	120 48.0	34 50.4	120 48.1	-	-	-	1	T
3	07/25	18	62/190	35 55.9	120 32.7	35 55.5	121 32.7	-	-	-	3	T
4	07/29	13	94/210	37 49.5	123 22.1	37 48.8	123 20.3	172	-	386	1	1
5	07/30	14	45/ 53	38 29.6	123 21.8	38 29.7	123 21.8	-	-	-	15	-
6	07/31	15	100/140	39 21.0	123 58.0	39 21.5	123 58.0	554	-	-	-	-
7	08/01	12	100/150	40 11.3	124 26.2	40 11.7	124 27.5	100	79	-	-	16
8	08/01	20	54/217	40 46.5	124 31.2	40 45.9	124 30.7	1387	-	-	-	11
9	08/02	15	96/522	41 21.6	124 34.5	41 23.1	124 33.1	148	-	-	-	12
10	08/02	18	95/155	41 24.6	124 29.9	41 25.0	124 30.0	3047	1	-	-	3
11	08/08	11	71/200	42 40.0	124 45.0	42 39.8	124 43.2	22	-	11	-	-
12	08/09	12	120/195	43 19.9	124 43.8	43 21.4	124 42.5	678	-	3	-	-
13	08/09	20	52/ 79	43 39.7	124 29.3	43 39.5	124 27.9	4150	-	-	-	-
14	08/10	16	116/620	44 00.1	125 00.6	44 00.1	124 59.5	7820	-	-	-	-
15	08/11	14	123/145	44 29.9	124 44.4	44 29.2	124 44.1	6370	-	-	-	-
16	08/12	13	78/ 86	45 00.0	124 16.6	45 00.0	124 15.4	2785	-	-	2	2
17	08/13	20	80/112	45 59.8	124 39.2	45 59.9	124 39.9	203	-	-	1	1
18	08/14	12	109/150	46 09.8	124 40.3	46 09.9	124 37.7	5753	9	-	-	88
19	08/16	08	20/ 32	47 29.9	124 35.9	47 29.8	124 36.6	2851	25	11	-	13
20	08/16	19	79/191	48 00.0	125 20.1	47 59.9	125 18.7	841	-	-	-	1
21	08/17	12	100/184	48 10.0	124 59.7	48 10.0	125 00.4	3239	-	-	1	-
22	08/19	10	30/ 39	49 00.3	126 05.1	49 01.2	126 12.4	-	-	-	-	1
23	08/20	13	117/175	49 16.8	127 08.3	49 16.3	127 07.4	1020	276	-	-	2
24	08/20	15	116/358	49 15.1	127 07.4	49 15.2	127 08.6	1273	31	-	7	8
25	08/21	13	107/185	49 50.1	127 43.0	49 49.9	127 42.4	2325	-	-	3	3

T = &lt; 1 lb.

Table 3. Numbers and types of Pacific whiting biological samples collected during survey cruise MF 89-05.

Haul #	Otoliths	lengths	Weights
1	49	99	49
2	-	-	-
3	-	-	-
4	50	136	50
5	-	-	-
6	100	337	100
7	85	101	85
8	83	392	83
9	79	118	79
10	80	373	80
11	18	18	18
12	100	405	100
13	90	289	90
14	90	368	90
15	102	322	102
16	97	307	97
17	115	165	115
18	111	358	111
19	81	294	81
20	92	325	92
21	82	311	82
22	-	-	-
23	82	318	82
24	79	304	79
25	75	268	75
Totals =	1740	5608	1740

Table 4. Estimated Pacific whiting biomass (1000 mt) by INPFC area for West coast survey cruise MF 89-05.

BY INPFC AREA

INPFC AREA	BIOMASS	CONFIDENCE INTERVAL (B $\pm$ 1.96*SD)		PERCENTAGE		
Conception	31.69	26.09	to 37.30	$\pm$ 17.7	%	
Monterey	209.44	160.86	to 258.02	$\pm$ 23.2	%	
Eureka	360.45	189.44	to 531.46	$\pm$ 47.4	%	
Columbia (S)	303.69	239.34	to 368.03	$\pm$ 21.2	%	
Columbia (N)	116.98	81.53	to 151.66	$\pm$ 30.1	%	
Vancouver (US)	137.41	30.61	to 244.20	$\pm$ 77.7	%	
Vancouver (Can-S)	27.62	24.10	to 31.15	$\pm$ 12.8	%	
Vancouver (Can-n)	76.98	27.30	to 126.65	$\pm$ 64.5	%	
Total =	1264.26					



Table 5. Estimated Pacific whiting population numbers (millions) at age, by INPFC areas, for West coast survey cruise MF 89-05.

INPFC AREAS									
AGE	CONCEP	MONT	EUREKA	COL (S)	COL (N)	VANCOUVER			TOTALS
						US	CAN-S	CAN-N	
0	1955.39								1955.39
1		1.43							1.43
2		142.08	105.43	7.80	0.71	0.38	0.06	0.01	256.47
3		30.77	29.49	5.98	2.28	0.70	0.13	0.26	69.62
4		5.36	8.44	3.72	1.53	0.91	0.18	0.40	20.53
5		170.74	437.38	337.52	135.78	115.80	23.21	55.64	1275.33
6		3.78	8.29	6.59	2.51	2.37	0.48	1.20	25.21
7		2.07	3.74	3.37	1.26	1.81	0.37	1.08	13.71
8		1.78	3.66	5.45	1.90	2.80	0.55	1.50	17.64
9		63.12	108.90	144.23	52.55	84.03	16.48	49.39	518.70
10		2.45	5.51	6.58	2.43	3.45	0.66	1.96	23.05
11		0.30	.37	0.82	0.32	0.52	0.11	0.33	2.76
12		6.06	4.84	6.91	2.96	5.88	1.47	5.09	33.22
13									
14									
15									
16		1.93		0.20	0.18	0.68	0.08	0.51	3.58
TOTALS	1955.39	431.88	716.04	529.18	204.41	219.35	43.77	117.37	4216.64

Table 6. Estimated Pacific whiting biomass (1000 mt) at age, by INPFC areas, for West coast survey cruise MF 89-05.

INPFC AREAS									
AGE	CONCEP	MONT	EUREKA	COL (S)	COL (N)	VANCOUVER			TOTALS
						US	CAN-S	CAN-N	
0	31.69								31.69
1		0.18							0.18
2		45.48	34.74	2.69	0.27	0.15	0.02	0.00	83.35
3		11.05	11.39	2.55	1.01	0.32	0.06	0.12	26.50
4		2.23	3.78	1.89	0.77	0.50	0.10	0.23	9.49
5		90.74	231.68	187.16	74.43	67.37	13.44	32.81	697.62
6		1.94	4.25	3.69	1.39	1.43	0.29	0.73	13.72
7		1.29	2.00	1.99	0.75	1.25	0.26	0.77	8.31
8		1.10	2.16	3.39	1.17	1.78	0.35	0.97	10.92
9		45.58	64.08	90.89	33.25	56.90	11.30	34.87	336.88
10		1.53	3.29	4.08	1.51	2.26	0.43	1.32	14.42
11		0.20	0.23	0.54	0.21	0.35	0.08	0.23	1.83
12		5.10	2.87	4.63	2.06	4.48	1.23	4.37	24.75
13									
14									
15									
16		3.01		0.19	0.16	0.61	0.08	0.55	4.60
TOTALS	31.69	209.44	360.45	303.69	116.98	137.40	27.62	76.98	1264.26

Table 7. Mean lengths (cm) of Pacific whiting at age 5 and 9, by INPFC area, and their deviations (cm) from grand mean lengths at age.

INPFC AREA	Whiting mean length (cm) by INPFC area				Deviations (cm) from grand mean length	
	AGE 5	(n)	AGE 9	(n)	AGE 5	AGE 9
MONT+EUREKA	43.5	232	45.6	68	-0.5	-1.1
COLUMBIA	44.0	443	46.0	190	0.1	-0.8
VANCOUVER	44.7	245	47.9	208	0.7	1.1
GRAND MEAN LEN.	44.1		46.8			

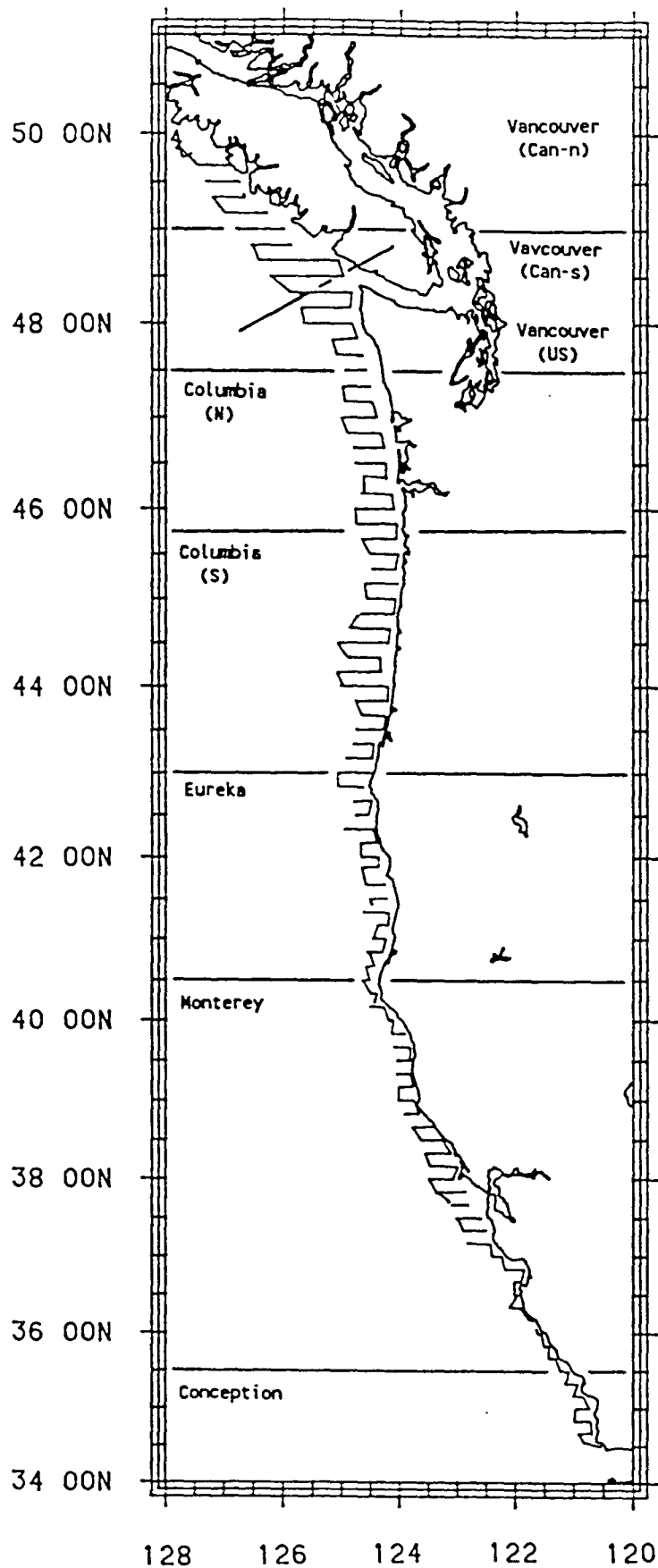


Figure 1. Locations of transects occupied during the 1989 Pacific whiting survey (cruise MF 89-05).

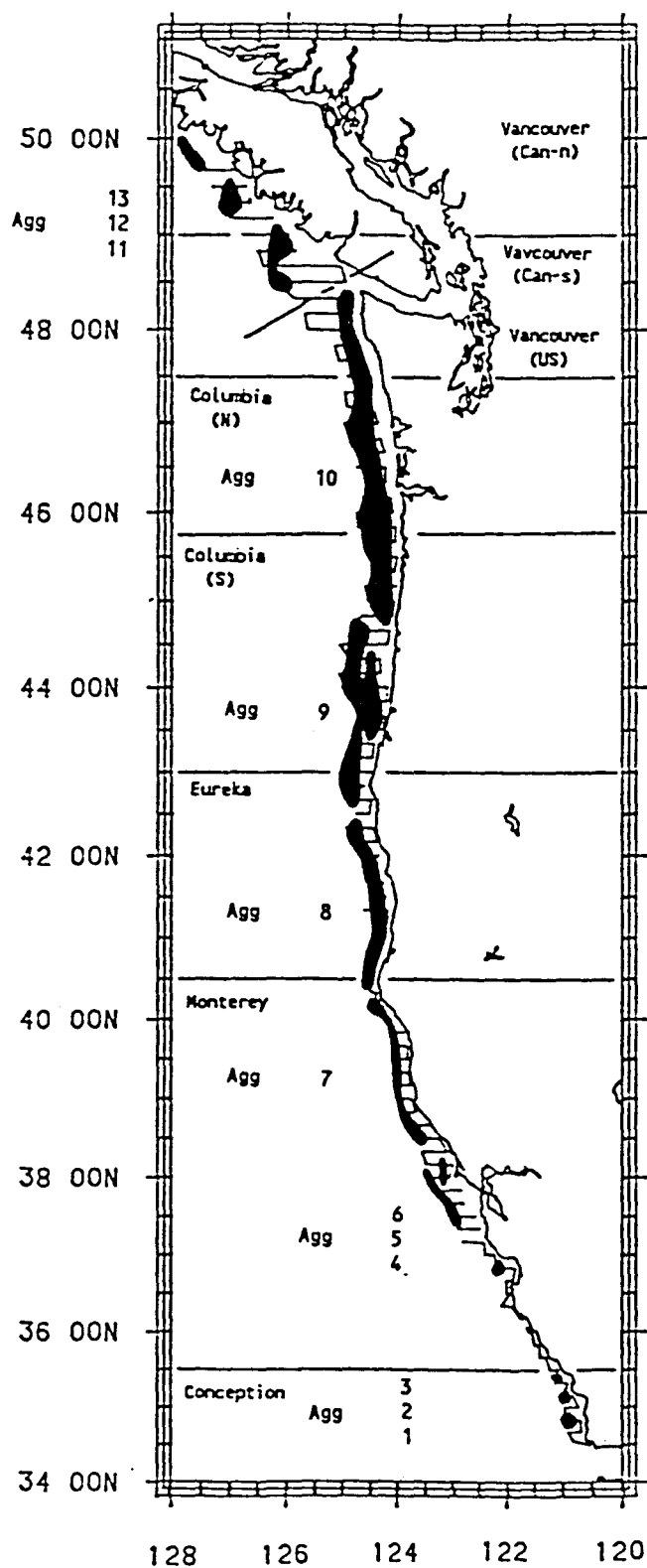


Figure 2. Approximate locations of whiting aggregations encountered during the 1989 Pacific whiting survey (cruise MF 89-05).

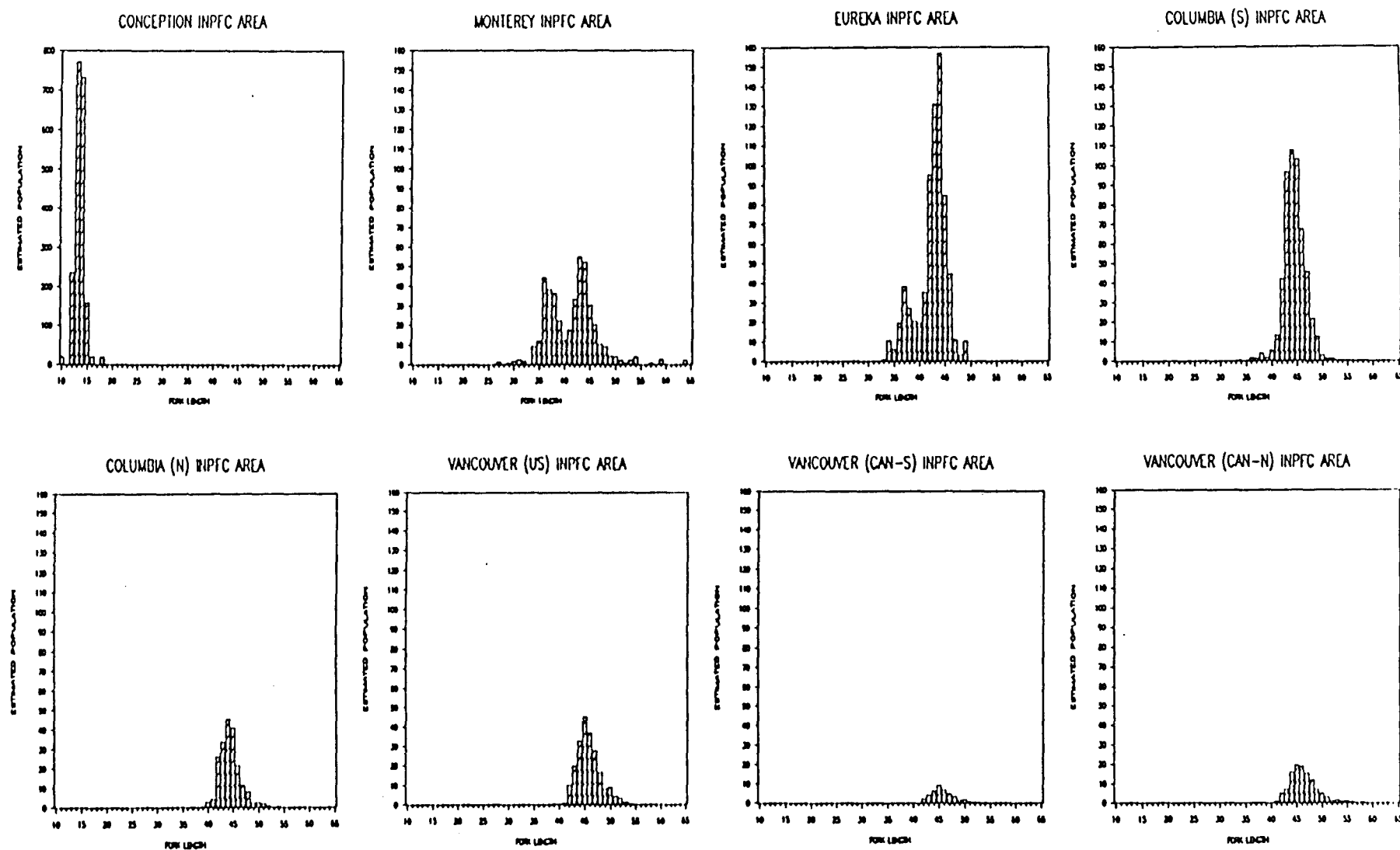


Figure 3. Population numbers (millions) at length for Pacific whiting by INPFC area (cruise MF 89-05).

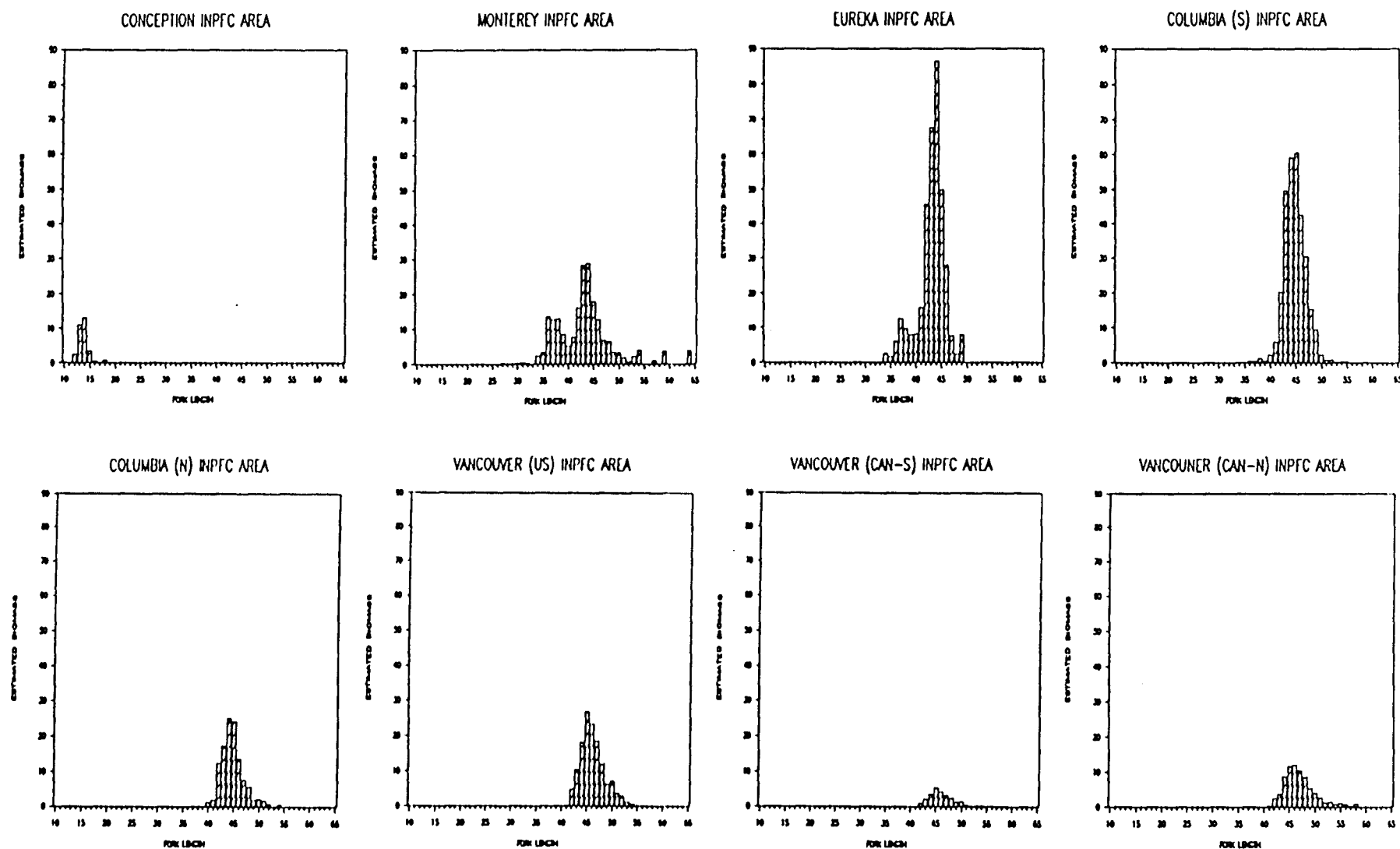


Figure 4. Population biomass (thousands mt) at length for pacific whiting by INPFC area (cruise MF 89-05).

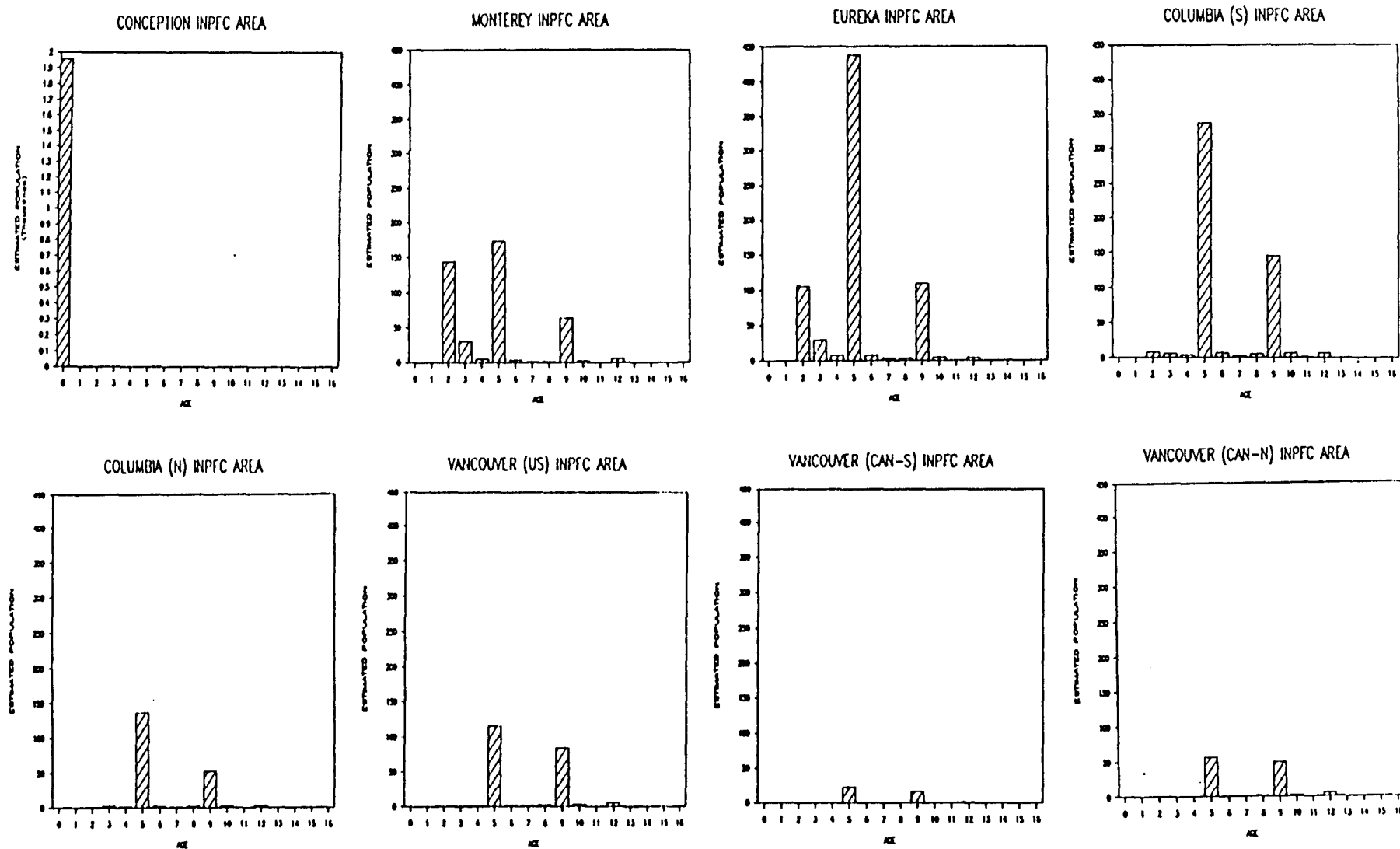


Figure 5. Population numbers (millions) at age for Pacific whiting by INPFC area (cruise MF 89-05).

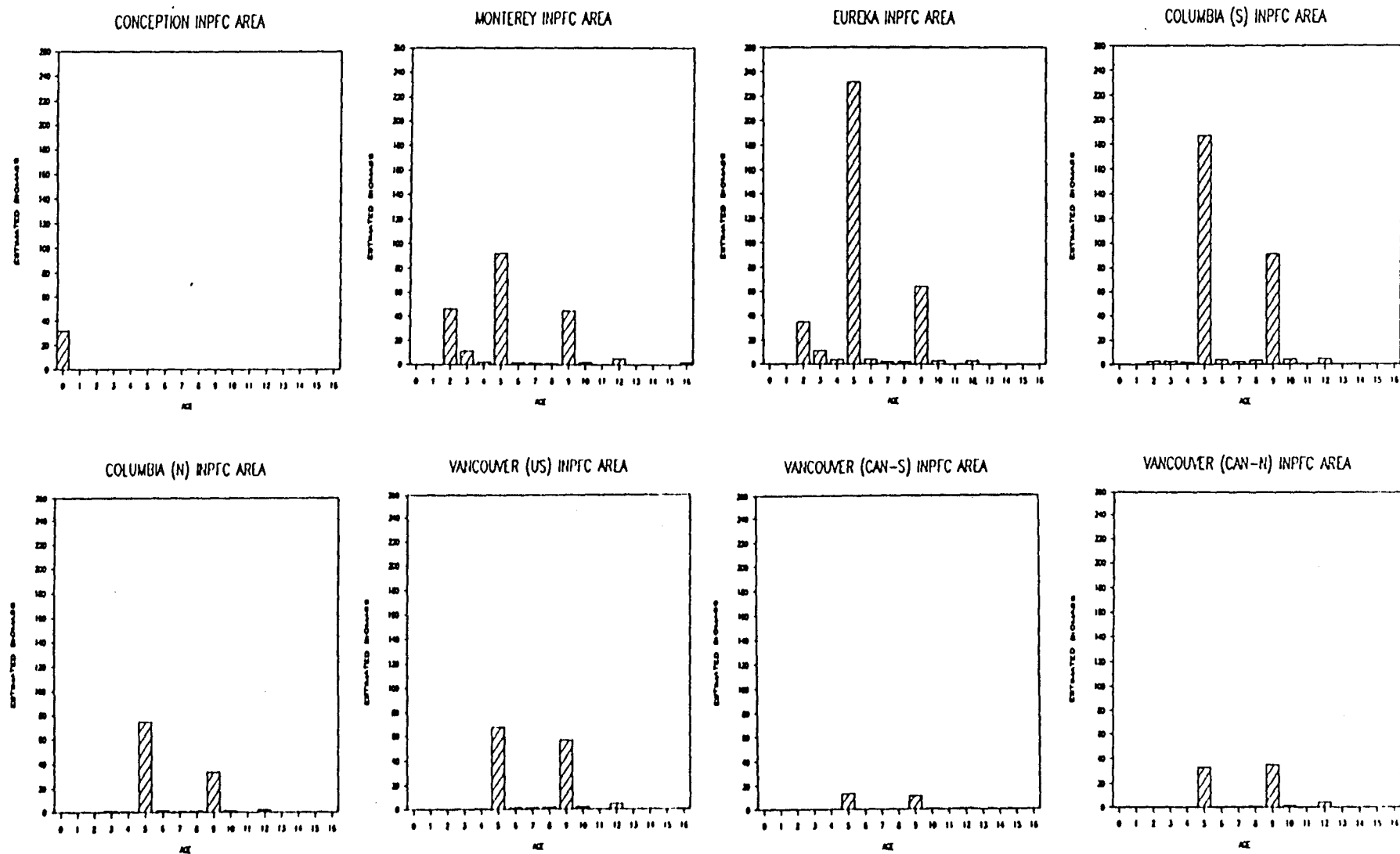


Figure 6. Population biomass (thousands mt) at age for Pacific whiting by INPFC area (cruise MF 89-05).



## LENGTH DEVIATION FROM GRAND MEAN

WHITING, AGES 5 &amp; 9 - BY INPFC AREA

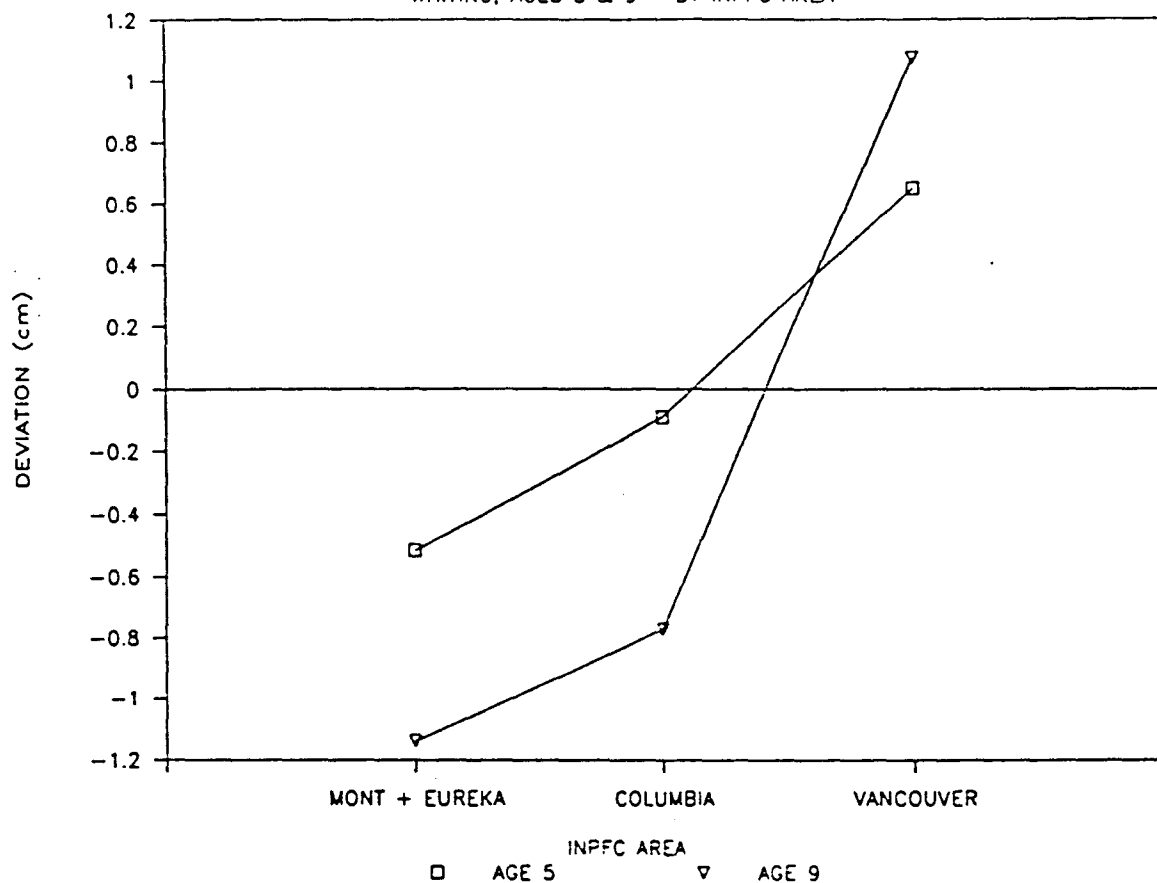


Figure 7. Deviations from grand mean length (cm) at age, by INPFC area, for Pacific whiting aged 5 and 9 years (cruise MF 89-05).